

TRACE ELEMENT ABUNDANCE DETERMINATIONS BY SYNCHROTRON X-RAY FLORESCENCE (SXRF) ON RETURNED COMET NUCLEUS MINERAL GRAINS, G. J. Flynn¹ and S. R. Sutton², (1) Dept. of Physics, SUNY-Plattsburgh, Plattsburgh, NY 12901, (2) Dept. of Applied Science, Brookhaven National Laboratory, Upton, NY 11973.

Trace element abundances and abundance patterns in meteorites have proven to be diagnostic indicators of fractionation in the solar nebula (1) or on meteorite parent bodies (2), cosmo-thermometers indicating nebula temperature at formation of the meteorites (3), internal thermometers indicating the maximum reheating experienced since formation (4), and a means of defining genetically related groups of meteorites (5). If, as expected, comets are more primitive samples of the solar nebula than the meteorites, then trace element abundances in the comet nucleus samples should be better indicators of solar nebula conditions than the patterns in the meteorite samples.

EXPECTED PROPERTIES: Some micrometeorites collected from the earth's stratosphere after atmospheric deceleration are likely to be samples of comets (6). These 5 to 50 μm micrometeorites are generally aggregates of mineral grains, predominantly olivine and pyroxene, typically smaller than 1 μm . Major element analyses by analytical Transmission Electron Microscopy (TEM) show varying major element compositions for nearby grains of the same mineral (7). Bulk chemical analyses with sampling volumes of order 1 μm^3 show wide variations in major element compositions at adjacent spots on the same particle (8). If the elemental heterogeneity of the cosmic dust particles is indicative of the variation in comet nucleus material, then both major and trace element analyses on micron and sub-micron mineral grain samples will be required for maximum information extraction. Analytical TEM will permit such analyses for major elements.

PRESENT/FUTURE SXRF TRACE ELEMENT CAPABILITIES: Trace element analyses have been performed on bulk cosmic dust particles by Proton Induced X-Ray Emission (PIXE) (9) and Synchrotron X-Ray Fluorescence (SXRF) (10). When present at or near chondritic abundances the trace elements K, Ti, Cr, Mn, Cu, Zn, Ga, Ge, Se, and Br are presently detectable by SXRF in particles of 20 μm diameter. A SXRF spectrum of a chondritic micrometeorite is shown in Figure 1. Details of this analysis are described by Sutton and Flynn (10).

Improvements to the SXRF analysis facility at the National Synchrotron Light Source presently underway should increase the range of detectable elements and permit the analysis of smaller samples. In addition the Advanced Photon Source will be commissioned at Argonne National Laboratory in 1995. This 7 to 8 GeV positron storage ring, specifically designed for high-energy undulator and wiggler insertion devices, will be an ideal source for an X-ray microprobe with one micron spatial resolution and better than 100 ppb elemental sensitivity for

most elements. Thus trace element analysis of individual micron-sized grains should be possible by the time of the comet nucleus sample return mission.

SAMPLE REQUIREMENTS: Sample collection, delivery, and curation must be accomplished in a manner to avoid contamination with even trace amounts of the elements to be analyzed. The present SXRF sensitivity for micrometeorite analysis is of order 10^{13} atoms (about 0.1 pg) (10). Improvements in sensitivity will require sample contamination substantially below this level. Sample collection and handling equipment should be constructed from materials selected for ultra-high purity.

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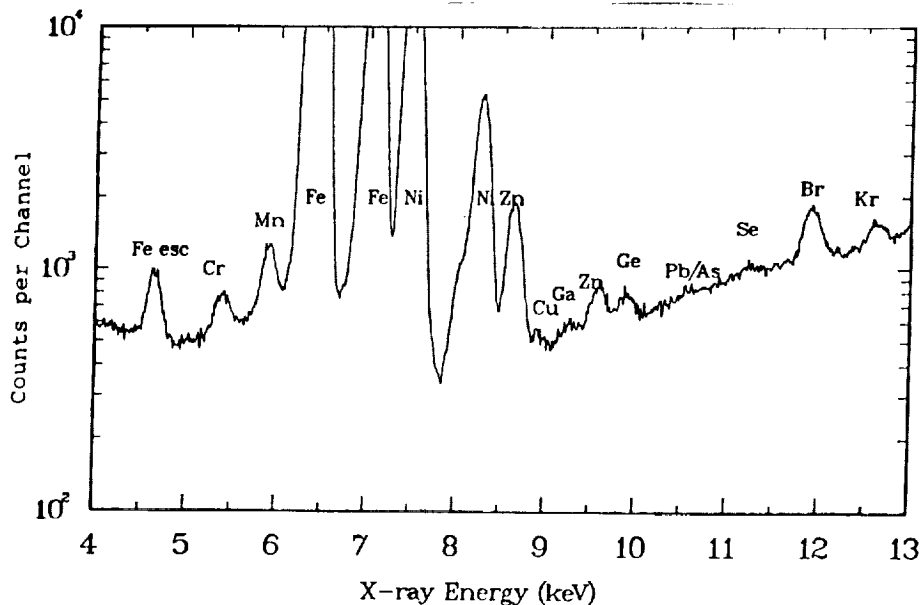


Figure 1. Synchrotron X-ray Fluorescence spectrum of micrometeorite U2022-G1, about 25 μm in diameter